NAVAL FACILITIES ENGINEERING SERVICE CENTER
Port Hueneme, California 93043-4370

Technical Report TR-6012-OCN

U.S. NAVY HEAVY WEATHER MOORING CRITERIA

by

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EXECUTIVE SUMMARY

It is standard procedure for U.S. Navy ships to go to sea prior to forecasted heavy weather, such as an approaching hurricane or major storm. However, some ships, such as ships under repair, ships under construction, harbor craft and other vessels may not be able to go to sea. These ships must be securely moored during heavy weather to piers, wharves or Fleet Moorings to ensure safety of the ships and surrounding structures and to prevent loss of life.

In 1999, NAVFAC and NFESC (Seelig, NFESC Report SSR-6150-OCN, 1999) examined the Hampton Roads, Mayport and Ingleside heavy weather support infrastructure for Commander, Naval Surface Forces Atlantic. We concluded that many facilities and moorings are inadequate to moor ships during heavy weather. In addition, a review of accident reports indicates that the Navy has incurred many tens of millions of dollars of accidents and ship movement costs, due to inadequate heavy weather moorings.

Three key deficiencies identified in these earlier studies are:

1) The lack of regional heavy weather mooring facility requirements,
2) The lack of consistent Navy-wide heavy weather environmental criteria, and
3) The inconsistency of analytical methodologies.

Therefore, this report:

- Proposes U.S. Navy 'heavy weather' (*Mooring Service Type III*) requirements by region. (Inactive, MSC and MARAD ships are not included in this report).

- Recommends Navy-wide 'heavy weather' environmental design criteria applied to key Navy regions.

- Provides technical guidance for the analysis, design, construction, and use of heavy weather mooring facilities.

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1.0 INTRODUCTION

It is standard procedure for U.S. Navy ships to go to sea prior to forecasted heavy weather, such as an approaching hurricane or major storm. However, some ships, such as ships under repair, ships under construction, harbor craft and other vessels may not be able to go to sea. These ships must be securely moored in heavy weather to piers, wharves or Fleet Moorings to ensure safety of the ships and surrounding structures and to prevent loss of life.

2.0 PURPOSE

In 1999, NAVFAC and NFESC (Seelig, NFESC Report SSR-6150-OCN, 1999) examined the Hampton Roads, Mayport and Ingleside heavy weather support infrastructure for Commander, Naval Surface Forces Atlantic. We concluded that many facilities and moorings are inadequate to moor ships during heavy weather. In addition, a review of accident reports indicates that the Navy has incurred many tens of millions of dollars of accidents and ship movement costs, due to inadequate heavy weather moorings. Therefore, Commander, Naval Facilities Engineering Command (COMNAVFACENGCOM) tasked the Naval Facilities Engineering Service Center (NFESC) to develop heavy weather mooring criteria.

Three key deficiencies identified in these earlier studies are:

1) The lack of regional heavy weather mooring facility requirements,
2) The lack of consistent Navy-wide heavy weather environmental criteria, and
3) The inconsistency of analytical methodologies.

Therefore, this report:

- Proposes U.S. Navy 'heavy weather' (*Mooring Service Type III*) requirements by region. (Inactive, MSC and MARAD ships are not included in this report).

- Recommends Navy-wide 'heavy weather' environmental design criteria applied to key Navy regions.

- Provides technical guidance for the analysis, design, construction, and use of heavy weather mooring facilities.

3.0 DEFINITIONS

To ensure common understanding of terminology, a glossary is provided below.

1. Destructive Weather – thunderstorms, tornadoes, tropical cyclones, extra-tropical storms, and severe windstorms (OPNAVINST 3140.24E). Tables 1 and 2 provide some definitions.

2. Destructive Weather Warning - a warning to indicate possible approaching destructive weather. Table 2 defines standard warnings (MIL-HDBK-1026/4).

3. Gale –winds of 34 to 47 knots (OPNAVINSTR 3140.24E).

4. Facility – any non-powered structure, fixed or floating, used to moor ships to restrict movement during weather. Facilities include piers, wharves, dolphins, mooring buoys and other specialized moorings.

5. Heavy Weather –
   a) *Mooring Service Type III* where wind speed is greater than 64 knots or the site specific 50-year return wind speed. MIL-HDBK-1026/4 “Mooring Design” (draft of 1998)
   b) winds in excess of 50 knots (COMNAVSEASYSCOM msg),
   c) wind of 50 knots and current of 3 knots acting concurrently and perpendicular to ship’s centerline tending to push ship away from pier (DDS 582-1),
   d) gales, storms, hurricanes, and destructive weather (COMNAVSEASYSCOM Standard Item 009-69).

6. Hurricane – a tropical cyclonic storm with sustained winds speeds greater than 64 knots.

7. Mooring - the system of lines, bitts, bollards, facility and fenders used to secure a ship. Moorings include items such as fenders, camels, lines, fittings, anchors, chain, structures, etc. The purpose of a mooring is to safely secure a ship.

8. Mooring Service Type - design criteria for moorings are based on risk of extreme events at each location in such a way that the risk of an accident is extremely low, and yet the costs are realistic. The longer a ship remains at a site and the more difficult it is to relocate, the more stringent the design criteria. Table 3 summarizes the four types of mooring service provided at DoD facilities, as defined in MIL-HDBK-1026/4 'Mooring Design'. Ships experience all four types during their service life with Types I & II being the most frequent

9. Normal Weather – winds less than 64 knots.

10. Safe Haven – Also called a hurricane haven. Defined as a berth or anchorage with sufficient strength and water depth to survive a storm with winds greater than 64 knots but less than the maximum design hurricane.

Table 1. STORM DEFINITIONS

Warning	***Distance Away***	***Wind Speed***	***Storm Surge***
EXTRA-TROPICAL			
Small Craft	N/A	18-33 knots	0
Gale	N/A	34-47 knots	0
Storm	N/A	48-63 knots	0
TROPICAL			
Tropical Depression	N/A	<33 knots	0
Tropical Storm	24 hours	34-63 knots	0
Hurricane Category I	N/A	64-82 knots	4-5 ft
Hurricane Category II	N/A	83-95 knots	6-8 ft
Hurricane Category III	N/A	96-113 knots	9-12 ft
Hurricane Category IV	N/A	114-135 knots	13-18 ft
Hurricane Category V	N/A	> 135 knots	> 18 ft

(after MIL-HDBK-1026/4 'Mooring Design')

Table 2. DoD STORM WARNINGS

Warning	***Definition***
WIND WARNINGS	
Small Craft Warning	Harbor and inland waters warning for winds 33 knots or less of concern to small craft.
Gale Warning	Warning for harbor, inland waters and ocean areas for winds 34 to 47 knots.
Storm Warning	Warning for harbor, inland waters and ocean areas for winds 48 knots or greater.
TROPICAL CYCLONE WARNINGS	
Tropical Depression	Warning for land, harbor, inland waters and ocean areas for winds 33 knots or less.
Tropical Storm	Warning for land, harbor, inland waters and ocean areas for winds 34 to 63 knots.
Hurricane/Typhoon	Warning for land, harbor, inland waters and ocean areas for winds 64 knots or greater.
THUNDERSTORM/TORNADO WARNINGS	
Thunderstorm Warning	Thunderstorms are forecast to impact the warning area.
Severe Thunderstorm Warning	Severe thunderstorms with wind gusts to 50 knots or greater and/or hail of 3/4 inch diameter or greater are forecast to impact the area.
Tornado Warning	Tornados have been sighted or detected by RADAR in or adjacent to the warning area, or have a strong potential to develop in the warning area.

(after OPNAVINST 3140.24E of 21 Dec 1993)

Table 2. DoD STORM WARNINGS (continued)

Warning	***Definition***
SPECIAL WEATHER ADVISORY/WARNINGS	Warnings may be issued for land, harbor, inland waters, or ocean areas as appropriate.
Winter Storm/Snow Warning	Warning may be issued for snow, mixed or freezing precipitation, wind chill, or anything that could impact operations. The parameters under which a winter storm warning will be issued are determined by local area commanders.
Storm Surge Warning	Warning issued for coastal areas, harbor, and inland waters when abnormally high tides are forecast to impact operations. The specific height above normal tide will be determined by local area commanders.
Other	May also encompass any additional weather phenomenon which may impact operations in the designated area.

(after OPNAVINST 3140.24E of 21 Dec 1993)

Table 3. MOORING SERVICE TYPES

MOORING SERVICE TYPE	*DESCRIPTION*
TYPE I	This category covers moorings which are used for **up to one month** by a vessel that **will leave** prior to an approaching tropical hurricane, typhoon or flood. Facilities include ammunition facilities, fueling facilities, deperming facilities, and ports of call. Use of these moorings is normally selected concomitant with forecasted weather.
TYPE II	This category covers moorings which are used for **one month or more** by a vessel that **will leave** prior to an approaching tropical hurricane, typhoon or flood. Facilities include general purpose berthing facilities.
TYPE III	This category covers moorings which are used for **up to two years** by a vessel that **will not leave** prior to an approaching tropical hurricane or typhoon. Facilities include fitting-out, repair, drydocking, and overhaul berthing facilities. Facilities providing this service are nearly always occupied. This mooring service is also referred to as "**Heavy Weather Mooring**".
TYPE IV	This category covers moorings which are used for **two years or more** by a vessel that **will not leave** in case of a hurricane, typhoon or flood. Facilities include inactive, drydock, ship museum and training berthing facilities.

(after MIL-HDBK-1026/4)

4.0 REGIONAL HEAVY WEATHER MOORING NEEDS

Each region where ships may be unable to sortie to sea has unique heavy weather mooring facility requirements. Some examples are discussed below:

HAMPTON ROADS, VA:

> COMNAVBASENORVAINST states that no site in the Hampton Roads region is appropriate as a safe haven during heavy weather. However, at any given time approximately 10% of the homeported ships will be unable to sortie to sea prior to a forecasted hurricane. These vessels are often under repair and thus require heavy weather moorings.

INGLESIDE, TX:

> In Ingleside, Texas, none of the homeported mine sweepers are fast enough to outrun a hurricane. Therefore, 100% of these vessels require heavy weather moorings. Other vessels such as service craft and inactive ships may also be unable to sortie to sea.

After consulting representatives from each region, we developed proposed regional heavy weather mooring facility requirements. This proposal is provided in Table 4 for the Atlantic Fleet and Table 5 for the Pacific Fleet. Each Regional Commander should validate this proposal for their region.

Table 4. RECOMMENDED HEAVY WEATHER MOORING REQUIREMENTS FOR THE ATLANTIC FLEET

I. NORTHEAST REGION

LOCATION	*NUMBER**	*SHIP CLASS*	*NOTES*
A. BATH, ME	0		
B. PORTMOUTH NSY	3	SSN 688	
C. SUBASE NEW LONDON	1	SSN 21	
" "	3	SSN 688	
D. EARLE, NJ	1	AOE	

II. MID-ATLANTIC REGION

LOCATION	*NUMBER**	*SHIP CLASS*	*NOTES*
A. NORFOLK NSY, NAB LITTLE CREEK, NAVSTA NORFOLK	2	CVN	
" "	2	LHA/LHD	
" "	5	LPD	
B. NEWPORT NEWS SHIPBUILDING	1	CVN	

NUMBER OF HEAVY WEATHER MOORINGS REQUIRED

Table 4. RECOMMENDED HEAVY WEATHER MOORING REQUIREMENTS FOR THE ATLANTIC FLEET (continued)

III. SOUTHEAST REGION

LOCATION	*NUMBER**	*SHIP CLASS*	*NOTES*
A. SUBBASE KINGS BAY, GA	1	SSBN 726	
" "	1	DDG 51	(1)
" "	1	FFG 7	(1)
B. NAVSTA MAYPORT, FL	2	CG 47	(2)
C. NAVSTA PASCAGOULA, MS	1	CG 47	
" "	1	FFG 7	
D. GULFPORT, MS	0		
E. NAVSTA INGLESIDE, TX	1	MSC 12	(3)
" "	24	MCM 1 & MHC 51	(3)
F. NAVSTA ROOSEVELT ROADS	VARIOUS	HARBOR CRAFT	(3)

(1) Needed as backup to Mayport, FL; see NFESC Report SSR-6176-OCN
(2) Designs in NFESC Report SSR-6078-OCN for DD-963, CG-47, DDG-51 and FFG-7
(3) NFESC provided designs and Fleet Moorings
NUMBER OF HEAVY WEATHER MOORINGS REQUIRED

Table 5. RECOMMENDED HEAVY WEATHER MOORING REQUIREMENTS FOR THE PACIFIC FLEET

I. NORTHWEST REGION

LOCATION	*NUMBER**	*SHIP CLASS*	*NOTES*
A. SUBBASE BANGOR, WA	5	SSBN 726	
" "	1	SSN 688	
B. NAVSTA EVERETT, WA	0		
C. PUGET SOUND, NSY	1	AOE	
" "	1	CVN	
" "	30	SUBS IN DISPOSAL	(1)

(1) NFESC designed/installed mooring, NFESC Report 55-95(03)

II. SOUTHWEST REGION

LOCATION	*NUMBER**	*SHIP CLASS*	*NOTES*
A. NAS NORTH ISLAND	0		
B. SAN DIEGO, CA	0		

NUMBER OF HEAVY WEATHER MOORINGS REQUIRED

Table 5. RECOMMENDED HEAVY WEATHER MOORING REQUIREMENTS FOR THE PACIFIC FLEET (continued)

III. PEARL HARBOR, HI REGION

LOCATION	*NUMBER**	*SHIP CLASS*	*NOTES*
A. PEARL HARBOR, HI	3	SSN	
" "	2	CG 47 OR DDG 51	
" "	4	MISC.	TRANSIENTS & DECOM**

IV. COMNAVMARIANAS, GUAM

LOCATION	*NUMBER**	*SHIP CLASS*	*NOTES*
A. APRA HARBOR	1	AS 40	USE FLEET MOORING?
" "	VARIOUS	HARBOR CRAFT	USE FLEET MOORINGS
" "	4	MISC.	TRANSIENTS & DECOM**

NUMBER OF HEAVY WEATHER MOORINGS REQUIRED
**Exact ship classes need to be determined.

Table 5. RECOMMENDED HEAVY WEATHER MOORING REQUIREMENTS FOR THE PACIFIC FLEET (continued)

V. USN FACILITIES JAPAN

LOCATION	*NUMBER**	*SHIP CLASS*	*NOTES*
A. SASEBO	0		SAFE HAVEN
B. YOKOSUKA	VARIOUS	HARBOR CRAFT	USE FLEET MOORINGS

VI. DIEGO GARCIA REGION

LOCATION	*NUMBER**	*SHIP CLASS*	*NOTES*
A. DIEGO GARCIA	0		

NUMBER OF HEAVY WEATHER MOORINGS REQUIRED

5.0 REGIONAL ENVIRONMENTAL DESIGN CRITERIA

Engineers must design Mooring facilities to moor ships in a safe manner that reduces risk to an acceptably low level. To obtain Navy-wide consensus, mooring engineers from NAVFAC, NAVSEA and SURFLANT gathered in August 1998 and developed general heavy weather mooring criteria. These attendees agreed that any heavy weather mooring must address the following environmental effects summarized in Table 6.

Table 6. DESIGN CRITERIA FOR HEAVY WEATHER MOORINGS
(*MOORING SERVICE TYPE III*)

Environmental Effect	***Probability of Occurrence***
High Winds	50 year recurrence (P=0.02)*
Swift Current	50 year recurrence (P=0.02)**
Extreme Water Levels	Extreme recorded levels (ELW / EHW)
Large Waves	Hindcasted from design high winds

*Use exposure D (American Society of Civil Engineers (ASCE) 7-95, Minimum Design Loads for Buildings and Other Structures; flat, unobstructed area exposed to wind flowing over open water for a distance of at least 1 mile (1.61 km) for determining design wind speeds.

**To define the design water depth, use T/d=0.9 for flat keeled ships; for ships with non-flat hulls, that have sonar domes or other projections, take the ship draft, T, as the mean depth of the keel and determine the water depth, d, by adding 0.61 meter (2 feet) to the maximum navigation draft of the ship.

Tables 7, 8 and 9 provide recommended heavy weather design criteria for selected regions. This document provides recommendations from a variety of sources with the Navy recommendation noted. Attendees at the August 1998 workshop unanimously agreed on the approach.

Table 7. *MOORING SERVICE TYPE III* DESIGN WIND SPEEDS

Site	Wind (ASCE)	Wind (Changery)	Wind (DM 26.6 '86)	Wind (DM 26.6 '68)	Recent Design Wind Speed	Recommended Heavy Weather Design Wind
Bath, ME	**95 mph**				73 mph obs	**95 mph**
Portsmouth NSY	**96 mph** **84 knots**	91 mph 79 knots	85 mph 74 knots	88 mph		**96 mph** ***84 knots***
SUBBASE New London	**101 mph** **88 knots**	87 mph 76 knots	115 mph 100 knots	119 mph	70 mph – SSN 115 mph– ARDM(Pier 17)	**100 mph** ***87 knots***
NAVSTA Earle, NJ	**104 mph** **90 knots**		100 mph 87 knots			**104 mph** ***90 knots***
Norfolk NSY	**92 mph** **80 knots**		110 mph 96 knots	113 mph		**95 mph** ***82 knots***
NAVSTA Norfolk	**100 mph** **87 knots**	98 mph 85 knots	110 mph 96 knots	113 mph	75 mph	**100 mph** ***87 knots***
NAB Little Creek	**103 mph** **90 knots**		105 mph 91 knots	106 mph	75 mph	**105 mph** ***91 knots***
Newport News Ship Building	**99 mph** **86 knots**		105 mph 91 knots	106 mph		**100 mph** ***87 knots***
SUBBASE Kings Bay	**101 mph** **88 knots**	87 mph 76 knots	150 mph 130 knots	N/A		**110 mph** ***96 knots***
NAVSTA Mayport	**110 mph** **96 knots**	84 mph 73 knots	150 mph 130 knots	157 mph		**110 mph** ***96 knots***
NAVSTA Pascagoula, MS	**120 mph** **104 knots**					**120 mph** ***104 knots***
NAVSTA Ingleside, TX	**126 mph** ***109 knots***				**126 mph** ***109 knots***	**126 mph** ***109 knots***
NAVSTA Everett	97 mph 84 knots	**65 mph** **56 knots**	85 mph 74 knots	94 mph	50 mph (CVN pier)	**85 mph** ***74 knots***
SUBBASE Bangor	75 mph 64 knots	**65 mph** **56 knots**	90 mph 78 knots	94 mph		**75 mph** ***64 knots***
Puget Sound NSY	75 mph 64 knots	**65 mph** **56 knots**	90 mph 78 knots	94 mph	80 mph (Pier D)	**75 mph** ***64 knots***
NAS North Island	80 mph 70 knots	**60 mph** **52 knots**	60 mph 52 knots	63 mph	60 mph (CVN wharf)	**60 mph** ***52 knots***
Pearl Harbor NSY	**96 mph** **84 knots**		60 mph 52 knots	63 mph	60 mph (SSN Y-2 wharf)	**100 mph** ***87 knots***
Yokosuka JAPAN					86 mph	
GUAM				120 mph	141 mph AFDM	**141 mph** *122 knots*
La Maddelana, ITALY					74 mph Med-moor	**102 mph** *89 knots*

NOTES FOR TABLE 7.

1) Wind speed (ASCE) is derived from "Minimum Design Loads for Buildings and Other Structures,"ASCE 7-95 for 50-year, 3-second gust, exposure C, converted to 30-second duration, exposure D (.84 x 1.086 for hurricane prone areas, .87 x 1.086 for others). NNSY, PSNS, SUBBASE Kings Bay, New London, and Bangor use exposure C. To obtain 100 year recurrence wind, multiply by 1.105 for east coast and 1.107 for west coast. To obtain 500 year recurrence wind, multiply by 1.33 for east coast and 1.23 for west coast. Wind speeds in Everett are in a special wind region addressed in the Commentary.
2) Wind speed (Changery/Simiu) is derived from "Historical Extreme Winds for the United States – Atlantic and Gulf of Mexico Coastlines," by M.J. Changery, NCC, NOAA, May 1982 and from "Extreme Wind Speeds at 129 Stations in the contiguous United States" by E. Simiu, NBS, March 1979. Both reports record fastest mile wind speeds which are converted to 30-second duration, exposure D (1.086 x 60/speed and Fig C6-1 of ASCE 7-95)
3) Wind (DM 26.6 '86) is based on current version of Navy Design Manual 26.6, "Mooring Design Physical and Empirical Data" (1986) for 30 second wind, highest average possible.
4) Wind (DM 26.6 '68) is based on previous version of Navy Design Manual 26.6, "Mooring Design Physical and Empirical Data" (1968) for 5- minute duration for highest average possible, converted to 30-second duration (x 1.25).

Table 8. *MOORING SERVICE TYPE III* DESIGN WATER LEVELS (in feet)

Site	Extreme High	Avg Yearly High	MHHW	MLLW	Avg. Yearly Low	Extreme Low	Recommended Heavy Weather High/Low
Bath, ME							8.7 /0.0 FEMA
Portsmouth NSY	12.78	11.30	8.90	0.00	-2.50	-3.00	12.8 / -3.0
SUBBASE New London	10.76	6.28	3.08	0.00	-2.30	-3.82	10.8 / -3.8
Norfolk NSY	8.85	6.15	3.15	0.00	-2.0	-2.40	8.9 / -2.4
NAVSTA Norfolk	8.39	5.60	2.80	0.00	-2.1	-3.21	8.4 / -3.2
NAB Little Creek	7.10		2.93	0.00		-2.50	7.1 / -2.5
Newport News Ship Building	8.39		3.15	0.00		-3.21	8.4 / -3.2
SUBBASE Kings Bay	9.11		7.04	0.00		-2.22	9.1 / -2.2
NAVSTA Mayport	7.50	6.40	4.92	0.00	-2.0	-3.20	7.5 / -3.2
NAVSTA Pascagoula, MS	6.13 (1980-1986)		1.78	0.00		-3.57	? / -3.6
NAVSTA Ingleside, TX	16.15		1.44	-0.25			16.15 / -0.25
NAVSTA Everett	14.35	13.31	11.11	0.00	-	-3.60	14.4 / -3.6
SUBBASE Bangor	14.67	13.33	11.13	0.00	-	-3.79	14.7 / -3.8
Puget Sound NSY	15.10	13.94	11.74	0.00	-3.90	-4.80	15.1 / -4.8
NAS North Island	8.35	7.50	5.73	0.00	-2.0	-2.88	8.4 / -2.9
Pearl Harbor NSY	3.51	-	1.95	0.00	-	-1.47	3.5 / -1.5
Yokosuka JAPAN			7.15	0.00			7.15 / 0.0
GUAM			2.4	0.00			4.7 / 0.0

1) Tidal benchmarks are from NOAA http://www.opsd.nos.noaa.gov/bench.html
2) Avg yearly high water and low water is from "Shore Protection Manual," USACE, 1984.
3) Extreme high values are from observations. For Norfolk, water levels above MLLW (assuming storm surge occurs at MHHW) are: 7.9 ft = 20 year storm; 8.9 ft = 50 year storm; and 9.8 ft = 100 year storm.

Table 9. *MOORING SERVICE TYPE III* DESIGN CURRENT VELOCITIES*

Site	Average Speed at maximum flooding	Avgerage Speed at maximum ebb	Recommended Heavy Weather Design Current Speed
Bath, ME			2.5 knots
Portsmouth NSY, N.H.(southside of island)	3.0 knots	3.8 knots	3.8 knots
SUBBASE New London, CT	0.1 knot	0.2 knots	0.2 knots
Norfolk NSY, VA	0.4 knots	0.3 knots	0.4 knots
NAVSTA Norfolk, VA	0.6 knots	0.8 knots	0.8 knots
NAB Little Creek, VA	0.3 knots	0.3 knots	0.3 knots
Newport News Ship Building, VA	0.9 knots	1.3 knots	1.3 knots
SUBBASE Kings Bay, GA	0.3 knots	0.3 knots	0.3 knots
NAVSTA Mayport, FL	2.2 knots	3.1 knots	3.1 knots
NAVSTA Pascagoula, MS	Weak	Weak	Weak
NAVSTA Ingleside, TX	2.0 knots	2.0 knots	2.0 knots
NAVSTA Everett, WA	0.6 knots	0.0 knots	0.6 knots
SUBBASE Bangor, WA	0.9 knots	1.1 knots	1.1 knots
Puget Sound NSY, WA	Weak	Weak	Weak
NAS North Island, CA	0.6 knots	0.6 knots	0.6 knots
Pearl Harbor NSY, HI	Weak	Weak	Weak
Yokosuka JAPAN	1.0 knot	1.0 knot	1.0 knot
Sasebo, JAPAN	Weak	Weak	Weak
GUAM			2.0 knots
Diego Garcia	Weak	Weak	Weak
La Maddelana, ITALY	Weak	Weak	Weak
Gaeta, ITALY	Weak	Weak	Weak

* Note: Current speeds and directions are highly dependent on location conditions. The designer should review these criteria for each specific berth to determine if the criteria apply or must be modified. When practical, it is recommended that measurements be made at the design site.

6.0 UNIFORM DESIGN METHODOLOGY

Engineers should perform preliminary designs and facility reviews using quasi-static methods in MIL-HDBK-1026/4 'Mooring Design'.

Since heavy weather results in extreme dynamic and non-linear movements, prepare final designs with full six-degree-of-freedom dynamic modeling. NFESC ECDET maintains this capability inhouse and is available to assist activities on a reimbursable basis.

A 'mooring' includes many parts and all parts are critical. Therefore, designs should ensure acceptable performance of:

- Facility mooring fittings (strength, condition and locations).
- Overall facility (based on strength and condition).
- Fendering.
- Ship hull (based on allowable hull pressures).
- Mooring lines (strengths, condition, angles, characteristics and use).
- Ship mooring fitting (strength and locations).
- Ship under-keel (clearance).
- Other factors (cost, access, permits, fire protection, utilities, etc.).

See MIL-HDBK-1026/4 'Mooring Design' for further information.

7.0 SUMMARY AND CONCLUSIONS

Typically, engineers design waterfront mooring facilities for *Mooring Type II*. However, in any given region a portion of these facilities must support *Mooring Service Type III* to account for ships in repair or unable to sortie in case of a major approaching storm. This report has outlined recommendations for number and type of regional Heavy Weather Moorings, regional environmental criteria, and design methods.

8.0 POINTS OF CONTACT

Points of contact concerning this report are provided in Table 10.

Table 10. POINTS OF CONTACT

NAME	***COMMAND***	***PHONE / EMAIL***
David Curfman	NAVFACENGCOM Criteria Office	757-322-4203 fax -4416 DSN 262-4203 *CurfmanRD@efdlant.navfac.navy.mil*
Larry Grafton	NAVSEASYSCOM Mooring Systems	703-602-1845 xt 216 *GRAFTON_CLARENCE_M@ hq.navsea.navy.mil*
Bill Seelig	NFESC 551 Moorings	202-433-2396 fax –5089 DSN 288-2396 SeeligWN@nfesc.navy.mil

9.0 REFERENCES AND BIBLIOGRAPHY

"Warnings and Conditions of Readiness Concerning Hazardous or Destructive Weather Phenomena," OPNAVINST 3140.24E dated 21 December 1993 *(Defines hazardous and destructive weather)*.

"Heavy Weather Mooring Guidance," message R 130351Z JUL 95 from COMNAVSEASYSCOM.

"Destructive Weather Plan," COMNAVBASENORVA/ SOPA (ADMIN) HAMPINST 3141.1V dated 23 Apr 1997 (*States that "none of the harbors in the Hampton Roads area are safe havens during sustained hurricane force winds."*)

"Destructive Weather Plan," NAVSHIPYDNOR/ SOPA (ADMIN) PORTINST 3140.1A dated 9 August 1994.

"Guidelines and Recommendations for the Safe Mooring of Large Ships at Piers and Sea Islands," TNL 81-4, Ref 1, Oil Companies International Marine Forum, dated 17 Feb 1981. (*Provides for 60 knot wind and ¾ knot beam current or 60 knot wind and 2 knot 10° current*)

"Hurricane Preparedness," 4700 Ser-N43/3450, ltr from COMNAVSURFLANT dated 12 Dec 1996.

"Heavy Weather Plan," NAVSEA Standard Item 009-69, 09 Dec 1994 (*Does not set upper environmental limit for heavy weather plan)*

"Heavy Weather Plan," NAVSEA Standard Item 009-69, 13 Sep 1996 (preliminary).

"Requirements for Entry to and Departure from the Contractor's Facilities," NAVSEA Standard Item 042-04, 27 Aug 1996 (*Requires a minimum water depth of navigable draft + 2 ft at Mean Lower Low Water which is inadequate for heavy weather. The ship will sit on the bottom at most berths. This requirement should be changed to navigable draft + 1 ft at Extreme Low Water)*

American Society of Civil Engineers, Minimum Design Loads for Buildings and Other Structures, ASCE 7-95, approved June 6,1996.

DDS 582-1, "Calculations for Mooring Systems," Naval Sea Systems Command, 16 Jan 1987.

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